TOPIC 08 – ACIDS/BASES
8.2 – PROPERTIES OF ACIDS AND BASES

IB Chemistry

T08D01

8.2 Properties of acids and bases - 1 hour

- 8.2.1 Outline the characteristic properties of acids and bases in aqueous solution. (2)
- Common acids are
  - Ethanoic – CH_3COOH
  - Sulfuric acid – H_2SO_4
  - Nitric acid – HNO_3
  - Hydrochloric acid – HCl
- Acids exhibit predictable behavior when dissolved in water to form a dilute solution

8.2 – Properties of Acids

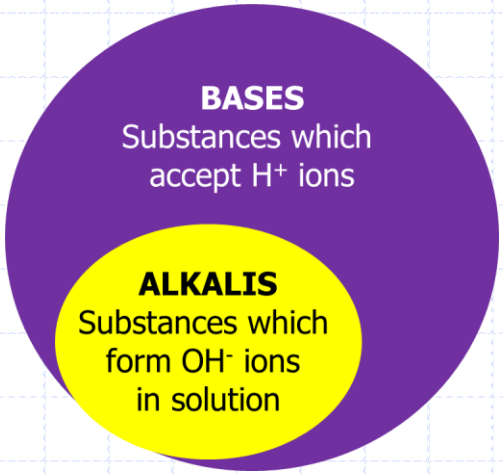
- Produce H^+ (as H_3O^+) ions in water
- Taste sour
- Corrode active metals (produce H_2 gas)
- React with bases to form salt and water
- pH is less than 7
- Turn litmus paper to Red
- React with carbonates and bicarbonates (CO_3^{2-} or HCO_3^-) to produce carbon dioxide gas (CO_2)
- Strong acids are strong electrolytes, weak acids are weak electrolytes

8.2 – Properties of Bases

- Produce OH^- ions in solution
- Taste bitter
- Feel soapy, slippery, denature proteins
- React with acids to form salt and H_2O
- pH is greater than 7
- Turns litmus paper to blue
- Strong Bases are good electrolytes, weak bases weak electrolytes
  - An **electrolyte** is a solution that undergoes chemical decomposition when an electrical current is passed through them (conductive)

8.2 – Bases in Solution

- Remember, just the soluble bases are considered to be alkalis and when added to water release an OH^- ion
  - $K_2O(s) + H_2O(l) \rightarrow 2K^+(aq) + 2OH^-(aq)$
  - $NH_3(aq) + H_2O(l) \rightleftharpoons NH_4^+(aq) + OH^-(aq)$
  - $CO_3^{2-}(aq) + H_2O(l) \rightleftharpoons HCO_3^-(aq) + OH^-(aq)$
  - $HCO_3^-(aq) \rightleftharpoons CO_2(g) + OH^-(aq)$



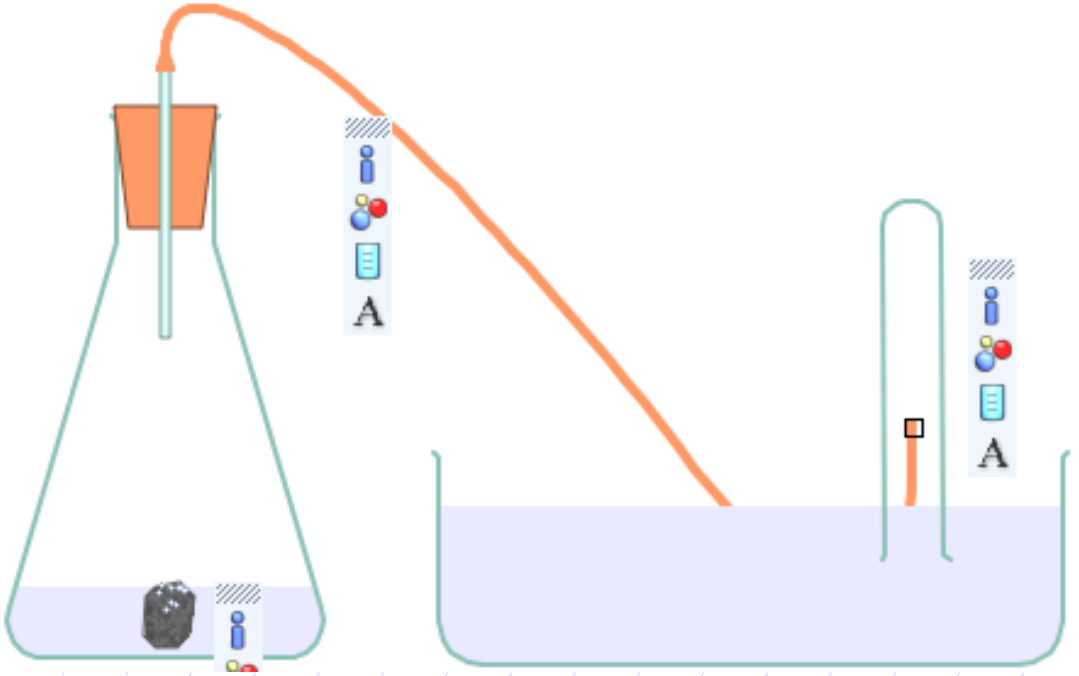
8.2 – Acids Reaction with Metals

- Most dilute acids react to produce H_2 gas and a solution of a salt when a reactive metal like, Mg, Fe, or Zn is added:
  - $Mg(s) + 2HCl(aq) \rightarrow MgCl_2(aq) + H_2(g)$
  - $Mg(s) + 2HNO_3(aq) \rightarrow Mg(NO_3)_2(aq) + H_2(g)$
  - $Mg(s) + H_2SO_4(aq) \rightarrow MgSO_4(aq) + H_2(g)$
  - $Mg(s) + 2CH_3COOH(aq) \rightarrow (CH_3COO)_2Mg(aq) + H_2(g)$
  - $Mg(s) + 2H^+(aq) \rightarrow Mg^{2+}(aq) + H_2(g)$
- In General:

Reactive metal + dilute acid → salt + hydrogen

8.2 – Collection of Hydrogen

- The more unreactive metals (such as Cu and Pb) do not react with dilute acids.
- Below is an apparatus for the collection of H_2 gas following the reaction



8.2 – Acid Reaction with Metal Carbonates

- Dilute acids react to give $CO_2(g)$ when a metal carbonate or metal hydrogencarbonate is added
  - $CaCO_3(s) + 2HCl(aq) \rightarrow CaCl_2(aq) + H_2O(l) + CO_2(g)$
  - $NaHCO_3(s) + HCl \rightarrow NaCl(aq) + H_2O(l) + CO_2(g)$
  - $CO_3^{2-}(aq) + 2H^+(aq) \rightarrow H_2O(l) + CO_2(g)$
  - $HCO_3^-(aq) + H^+(aq) \rightarrow H_2O(l) + CO_2(g)$
- In general
  - $(M)CO_3$ + acid → salt + water + carbon dioxide
  - $(M)HCO_3$ + acid → salt + water + carbon dioxide

8.2 – Acid Reaction with Bases

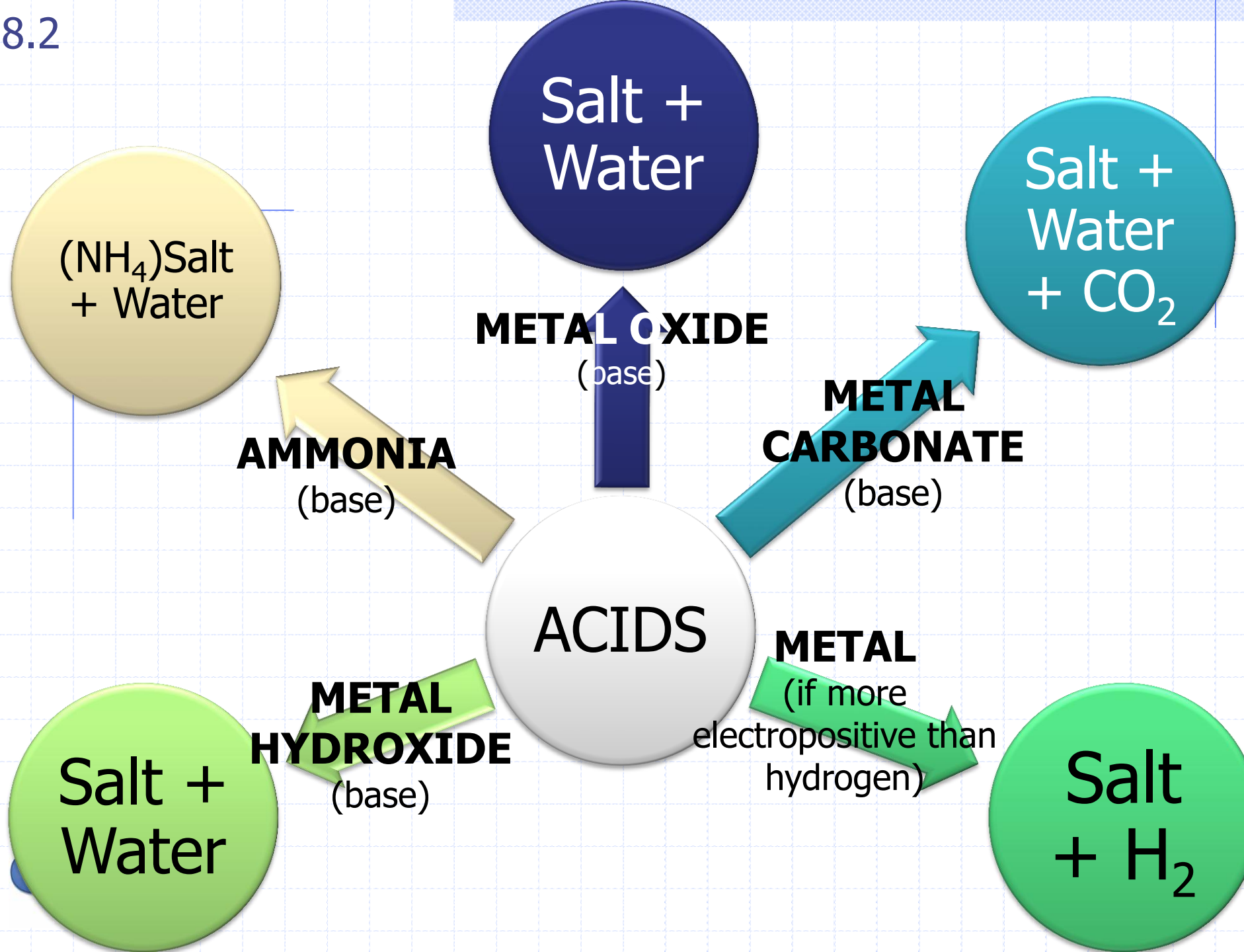
- Bases include:
  - Metal Hydroxides (NaOH, $Mg(OH)_2$, etc
  - Metal oxides (MgO, K_2O, etc – Topic 03)
  - Aqueous ammonia
- A base is a substance that reacts with an acid to form water and a salt only, this is known as **neutralization**
- Alkalis are bases that are soluble in water
  - Group I hydroxides (NaOH, KOH, etc)
  - $Ba(OH)_2$
  - NH_3 (aka NH_4OH – ammonium or ammonium hydroxide

8.2 – Acid Reaction with Metal Oxides

- Dilute acids react to give salt and water when a metal oxide is added:
  - $CuO(s) + H_2SO_4(aq) \rightarrow CuSO_4(aq) + H_2O(l)$
  - $CuO(s) + 2HNO_3(aq) \rightarrow Cu(NO_3)_2(aq) + H_2O$
  - $CuO(s) + 2HCl(aq) \rightarrow CuCl_2(aq) + H_2O(l)$
  - $CuO(s) + 2CH_3COOH(aq) \rightarrow Cu(CH_3COO)_2(aq) + H_2O(l)$
  - $O^{2-}(s) + 2H^+(aq) \rightarrow H_2O(l)$
- In general:
  - Metal oxide + dilute acid → salt + water

8.2 – Acid Reaction with Metal hydroxides

- Dilute acids react to give salt and water when a metal hydroxide or aqueous ammonia is added
  - $NaOH(aq) + HNO_3(aq) \rightarrow NaNO_3(aq) + H_2O(l)$
  - $NH_3(aq) + HNO_3(aq) \rightarrow NH_4NO_3$
  - $OH^-(aq) + H^+(aq) \rightarrow H_2O(l)$
  - $NH_3(aq) + H^+(aq) \rightarrow NH_4^+(aq)$
- In general:
  - Metal hydroxide + dilute acid → salt + water


Salt + Water
(NH_4)Salt + Water
Salt + Water + CO_2
METAL OXIDE
(base)
AMMONIA
(base)
METAL CARBONATE
(base)
ACIDS
METAL HYDROXIDE
(base)
METAL
(if more electropositive than hydrogen)
Salt + Water
Salt + H_2

8.2 – The importance of H_2O

- An **anhydrous** acid is one that is not dissolved in water
- The properties described are only applied for aqueous acid dissolved in water to form dilute acids
- This can be demonstrated by dissolving hydrogen chloride gas (HCl(g)) in both water and the organic liquid methylbenzene ($C_6H_5CH_3$)

Test	Soln of HCl in water	Soln of HCl in $C_6H_5CH_3$
Universal Indicator Paper	Turns red	Remains green – neutral
Addition of $CaCO_3$	CO_2 gas produced	No reaction
Electrical Conductivity	Good Conductor	Non-Conductive
Enthalpy of Solution	Exothermic	Very little change

8.2 – Importance of H_2O cont..

- The previous results are due to:
  - Ions formed when HCl is dissolved in water
    - $HCl(g) + (aq) \rightarrow H^+(aq) + Cl^-(aq)$
  - It's the H^+ ions that are responsible for the acidic properties which are only formed in water
  - The Cl^- ions also aid in the conductivity of the solution
  - In methylbenzene, the undissociated form of HCl(solv) are present

8.2 – "hardness" of water

- In your travels you may come across water that does one of two things when you shower:
  - The soap simply doesn't lather leaving a scummy residue
    - Basic water is "hard"
    - Soap is basic, and rinsing with basic water does not help to clear it away
  - The soap rinses right of, with a feeling that it doesn't clean well.
    - Acidic water is "soft"
    - Contains many ions, such as calcium deposits left by $CaCO_3$ – can be treated by water softeners (acids)

8.2 – Extras: Salts

- In diprotic or dibasic acids, containing more than one available hydrogen, salts can be added to form **normal salts** (total replacement) or **acid salts** (partial replacement).

Acid	Salt	Example
HCl	Chlorides	NaCl
HNO_3	Nitrates	$NaNO_3$
CH_3COOH	Ethanoates	CH_3COONa
H_2SO_4	Sulfates (normal salts) Hydrogensulfates (acid salts)	Na_2SO_4 $NaHSO_4$
H_2CO_3	Carbonates (normal salts) Hydrogencarbonates (acid salts)	Na_2CO_3 $NaHCO_3$